PTO 08-7058

CC = EP
19800430
A1
0010464

METHOD AND DEVICE FOR THE STARTUP OF A CRYOGENIC LIQUID PUMP
[Procédé et dispositif de démarrage d'une pompe à liquide cryogénique]

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UNITED STATES PATENT AND TRADEMARK OFFICE
WASHINGTON, D.C. AUGUST 2008
TRANSLATED BY: THE MCELROY TRANSLATION COMPANY

PUBLICATION COUNTRY	(19):	EP
DOCUMENT NUMBER	(11):	0010464
DOCUMENT KIND	(12):	A1
PUBLICATION DATE	(43):	19800430
		Bulletin 80/9
APPLICATION NUMBER	(21):	79400677.5
APPLICATION DATE	(22):	19790925
INTERNATIONAL CLASSIFICATION[3]	(51):	F 04 B 49/02
		F 04 D 9/00
PRIORITY NUMBER	(30):	7830114
PRIORITY DATE	(30):	19781023
PRIORITY COUNTRY	(30):	FR

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DESIGNATED CONTRACTING STATES	(84):	CH, DE, FR, GB, IT, NL, SE

TITLE (54): METHOD AND DEVICE FOR THE STARTUP OF A CRYOGENIC LIQUID PUMP

FOREIGN TITLE [54A]: Procédé et dispositif de démarrage d'une pompe à liquide cryogénique

The present invention relates to a method and a device for starting a cryogenic liquid pump which, /1*
under normal conditions of operation must always generate an increase in the total pressure of a fluid between a suction orifice and a lift orifice.

The proper operation of such a pump requires the existence during suction of an excess pressure compared to the instantaneous pressure of the vapor at this point. In the absence of such an excess pressure, the liquid tends to vaporize due to the effect of the low pressure generated by the pump. Thus vapor bubbles form that can prevent the "startup" of the pump. Another consequence of the existence of these vapor bubbles is the phenomenon called "cavitation." These bubbles are unstable and they "implode"; the result is shocks that rapidly damage the pump.

To prevent these disadvantages (startup, cavitation) the liquid must be at an excess pressure with respect to the vapor pressure. This excess pressure is generally referred to by the English acronym NPSH, which is the abbreviation for "net positive suction head."

The NPSH depends on the pressure and on the temperature of the fluid, which, in the case of a cold fluid, requires prior cooling of the pump to ensure the existence of a sufficient NPSH. For this purpose, the user uses generally two valves, one of which allows increasing the pressure during suction, and the other of which allows cooling the pump by circulating liquid through it.

In practice, the user evaluates whether the NPSH required has been reached in different ways:

– Most of the time by means of a visual reference to the state of frost formation on the pump (for example: the frost has reached the middle of the spacer arms separating the pump from the motor);

– By waiting for a sufficiently long period, as determined from experience;

– In the most advanced installations, by using a temperature probe.

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* [Numbers in right margin indicate pagination of the original text.]

When the user considers the cooling to be sufficient, he starts the pump and verifies on the lift manometer that the priming has taken place effectively, then he lets the pump function and stops it /2 when the quantity to be transferred has been reached (estimation resulting from the examination of a level, a counter, a scale).

This way of proceeding presents the following disadvantages:

– The startup conditions depend on the evaluation of the operator and are consequently rarely optimized (insufficient NPSH or waiting period too long). The result is premature wear of the pump, and loss of time. It should be noted that, even in the case of the use of a temperature probe, there is no exact indication of the NPSH, since it depends on both the pressure and the temperature.

– In the case of a startup with insufficient NPSH, the pump is not primed, and it turns under poor conditions until the operator stops it.

– During the operation of the pump, if an accident occurs (insufficient NPSH, loss of priming), the pump continues to turn until the operator stops. If the operator has gone away, or let his attention lapse, the pump turns under poor conditions and deteriorates.

The purpose of the invention is to overcome the above reported disadvantages and to allow a reliable startup of the cryogenic pump under good operating conditions, or, if the operation occurs under unsatisfactory conditions, the immediate stoppage of said pump.

According to the method of the invention, one equips a pump for cryogenic liquid with a device for measuring the excess pressure of the liquid present during the suction of the pump compared to the vapor pressure, or NPSH, and with a device for measuring the excess pressure of the lift compared to the inlet pressure, or the lift pressure of said pump, with a means to compare said NPSH and said excess pressure or lift pressure with two respective nominal values, where said means controls a power supply device for the motor of the pump, and one proceeds, after cooling the pump, to conduct startup tests. /3

which is [sic] carried out only if the value of the NPSH measured at that time is greater than said nominal value, and which is continued beyond a brief test time only if the excess pressure of lift or the lift pressure is greater than the nominal value.

The invention relates to a device that uses said method.

The invention will now be described in reference to the attached drawings in which:

– Figure 1 is a schematic view of a pump installation according to the invention;

– Figure 2 is a detail view of an embodiment of the automatic control device for controlling the startup of the pump.

In reference to Figure 1, a reservoir 1 for a cryogenic liquid 2 is connected by a pipe 3 to a utilization receptacle which is not shown, this pipe 3 incorporates a cryogenic pump 4 with a drive motor 5, and, on both sides of the pump 4, inlet valve 6 and lift valve 7 are arranged. Between the valve 6 and the pump 4, a shunt duct 8 is arranged, which duct is equipped with a valve 9 leading to a heater 10 that is connected by a pipe 11 to a high end of the cryogenic reservoir 1.

Between the pump 4 and the lift valve 7, a second shunt 12 with a valve 13 is provided, which shunt serves to cool the pump.

One provides a device 20 for measuring the NPSH, which may be constructed differently, but which, in the example represented, comprises a differential pressure switch 21 and a temperature measuring device 22 which performs the measurement on the fluid flowing through the pipe 3 in front of the pump 4. In the embodiment represented, the measuring device 22 is here formed from a bulb inflated with a gas of the same nature as the fluid to be pumped and at a pressure such that the ambient temperature is /4 equal to at least the maximum operating temperature of the supply reservoir 1 of the pump. One can also inflate the bulb with a fluid of a different nature than the fluid to be pumped, whose vapor pressure curves, however, are similar (example: argon, oxygen); in this case, one must take into account the

difference in the vapor pressures for the regulation of the differential pressure switch which is sensitive to the difference between the pressure measured at the location of the device 21 and that given by the bulb 22.

Besides the measurement device 20 for measuring the NPSH, one provides a measurement device 30 for measuring the differential pressure between the inlet and the lift of the pump 4. This differential pressure measuring device collects the pressures at the location of the device 21 used for the NPSH measuring device and at a location 32 in the vicinity of the lift opening of the pump 4.

These two devices 20 and 30 for measuring the NPSH and the excess pressure of lift, respectively, act on a comparison device 40 which ensures, when the conditions are required, the startup of the power supply device 50 of the motor of the pump 5, as follows:

One compares, in the device 40, the value of the measurements of the NPSH and of the excess pressure of lift to the nominal values, and one ensures the start and the stop of the motor of the pump as a function of the position of the measured values of NPSH and of the excess pressure of lift to the nominal values, taking into account the start and stop commands that are supplied by the operator or by other control devices (fire safety, threshold temperature safety…).

The device 40 is designed to function as follows:

– the operator performs the actuation of the valves 7 and 13 required for the cooling of the pump, then he pushes a startup button of the power supply device 50, and, after these actuations, the device 40 registers the startup command and checks the value of the NPSH:

· If the NPSH reaches or exceeds the nominal value, the device 40 issues the startup command to the motor 5 of the pump 4; /5

· If, in a fixed brief time period, for example 5 sec, the lift pressure has not exceeded the nominal value, the device 40 stops the pump motor and delivers an error message;

· If the lift pressure has exceeded the nominal value (pump is primed), the operation continues as long as the NPSH and the lift pressure remain higher than the respective nominal values and no external stop order has been given.

Shutting off of the pump is accomplished manually by the operator.

A special embodiment, with further details on some aspects, is described now, in reference to Figure 2, of an embodiment according to the invention relating to a pump provided to lift 20 m^3/h liquid nitrogen by suction in a reservoir at 0.2 MPa (2 bar absolute) and by lifting at 1.7 MPa (17 bar absolute). The NPSH measuring device consist of a differential pressure switch whose low pressure intake is connected to a tube that ends with a small sealed capacity, immersed in the suction piping of the pump in the vicinity of the latter's inlet connector clamp. This capacity is put under a vacuum beforehand, then loaded with gaseous nitrogen at 0.3 MPa (3 bar absolute) at ambient temperature. The high pressure intake of the pressure switch is connected to the suction piping of the pump in the vicinity of the latter's inlet clamp.

The nominal value of this pressure switch is regulated at 0.04 MPa (0.4 bar) so that, when the vapor pressure of the nitrogen at the output temperature of the pump is more than 0.04 MPa less than the suction pressure of the pump, an electrical contact C1 of the pressure switch closes.

The device for measuring the excess pressure of lift consists of a simple pressure switch whose pressure intake is connected to the lift piping of the pump. The setting of this pressure switch is regulated at 1 MPa (10 bar) so that, when the lift pressure of the pump exceeds 10 bar, an electrical contact C2 of the pressure switch closes.

The automatic device 40 performs the above-described functions. It is provided to be intercalated in /6 the control and power supply device of the motor 5 of the pump 4. This motor 5 is supplied with power as a three-phase current, where the three phases are represented by the letters R, S, and T, respectively. The control

The operation of the device 40 is described now, after a reminder of the conventions used in electrical schemata: when the coils of the relays (R1, R2, R3, R4) are supplied with power, the contacts of these relays are shifted from right to left or from top to bottom

When the operator pushes the On button M, the relay R1 is excited through the contact R2b, which causes the closure of the self-maintenance contact R1a of this relay, as well as the closing of the contacts R1b and R1c. The motor of the pump, however, is not supplied with power. The previous state is maintained until the closure of the external contact C1 (NPSH). The closing of the contact C1 causes the power supply for the relay R3. The contacts R3a and R3b close. The closing R3b causes power supply for the relay R2 through the contacts R1b and R3b.

The power supply for the relay R2 causes:

– the self-maintenance of this relay R2 via the closure of the self-maintenance contact R2a;

– the closing of the contact R2c, and

– the delayed opening (5 sec) of R2b.

The motor 5 of the pump is supplied with power through the intermediary of the relay R4 which receives power through R1c and R2c.

If the pump is primed within five seconds, the contact C2 closes, and the power supply for the relay R1 is ensured through R1a, R3a, and C2. The pump functions as long as the contacts C1, C2 and A remain closed.

If the pump does not become primed, the contact C2 does not close, and, after 5 sec, the contact R2b opens.

The relay R1 is no longer supplied with power, the contact R1c opens, and the pump motor 5 stops. /7

During the operation of the pump, the opening of one of the contacts C1 or C2 also causes the stoppage of the pump.

The invention applies to the field of the distribution of cryogenic or frigorific fluids.

Claims /8

1. Method for the startup of a pump for cryogenic fluid, characterized in that one equips said pump with a device for measuring the excess pressure of the liquid present during pump suction compared to its vapor pressure during suction, where this excess pressure is referred to as NPSH, and with a device for measuring the excess pressure of lift compared to the inlet pressure of the lift pressure of said pump, with a means for comparing said NPSH and said excess pressure or lift pressure with two respective nominal values, and with a means for controlling a power supply device for the motor of the pump, and one proceeds, after cooling the pump, to startup tests which is [sic] carried out only if the NPSH value measured at this instant is greater than said nominal value and which is continued beyond a brief test time only if the excess pressure of lift is greater than its nominal value.

2. Method for the startup of a pump according to Claim 1, characterized in that one carries out the measurement of the NPSH by measuring the pressure and the temperature of the liquid in the vicinity of the pump.

3. Device for the startup of a pump for cryogenic liquid comprising a device for measuring the NPSH with measurement of the pressure during suction and the temperature during the suction of said pump, a device for measuring the excess pressure or lift pressure of the pump, and comparison means for comparing these measurements with the nominal values, where said comparison means control the startup device of the motor of the pump.

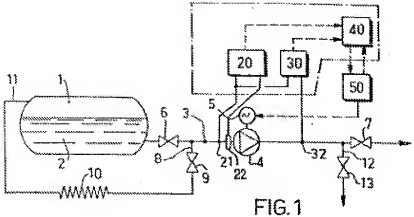
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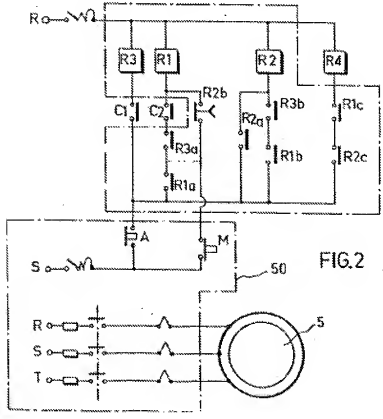
FIG. 1


R
R3
R1
R2
R4
C1
C2
R2b
R3b
R1c
R2a
R3a
R1b
R2c
R1a
A
M
S
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R
S
T
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FIG. 2

European Patent Office

Application Number EP 79 40 0677

EUROPEAN SEARCH REPORT

DOCUMENTS CONSIDERED TO BE RELEVANT			CLASSIFICATION OF THE APPLICATION (Int. Cl.[3])
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	F 04 B 49/02 F 04 D 9/00
A	GB – A – 1 449 852 (COPPEN) * The whole document * -----	1	
A	DE – A – 1 653 732 (K. S. B.) * The whole document * -----	1	TECHNICAL FIELDS SEARCHED (Int. Cl.[3])
A	FR – A – 2 374 538 (MATERIEL TELEPHONIQUE) * The whole document * -----	1	F 04 B F 04 D G 05 D
			CATEGORY OF CITED DOCUMENTS X: Particularly relevant if taken alone. A: Technological background. O: Non-written disclosure. P: Intermediate document T: Theory or principle underlying the invention. E: Earlier patent document, but published on, or after the filing date. D: Document cited in the application. L: Document cited for other reasons.
X	The present search report has been drawn up for all claims.		&: Member of the same patent family, corresponding document.

Place of search	Date of completion of the search	Examiner
The Hague	January 21, 1980	Heinlein